

Precise Position Capture with Radar Satellites

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Munich Flashlights
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Wissen für Morgen



Precise Position Capture with Radar Satellites

Problem:

Sometimes it is difficult, too dangerous or too expensive to be on site for a position measurement

Solution:

Combination of GNSS and Radar Satellite Remote Sensing

Best of both worlds:

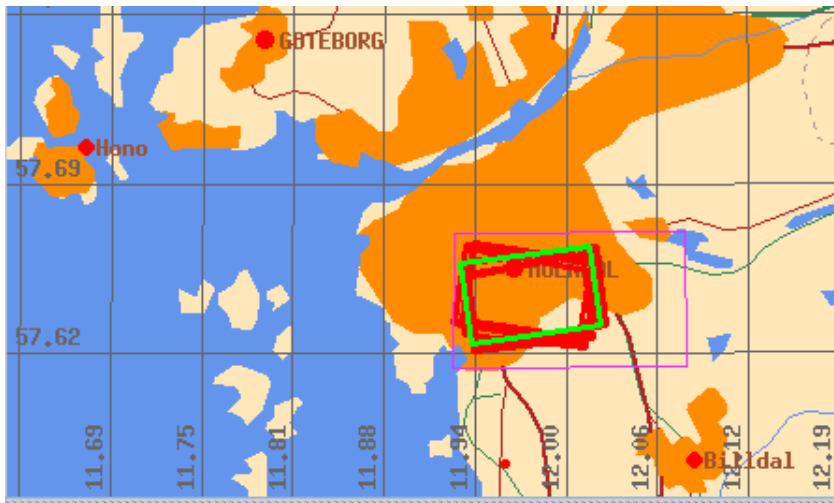
High precision from GNSS and distance measurement with Satellite Radar



We use our Radar-Satellites TerraSAR-X and TanDEM-X to produce dense nets of Ground Control Points (GCPs) with geodetic accuracy

Example: Gothenburg / Sweden

Scene Size: 2,5 km x 6km

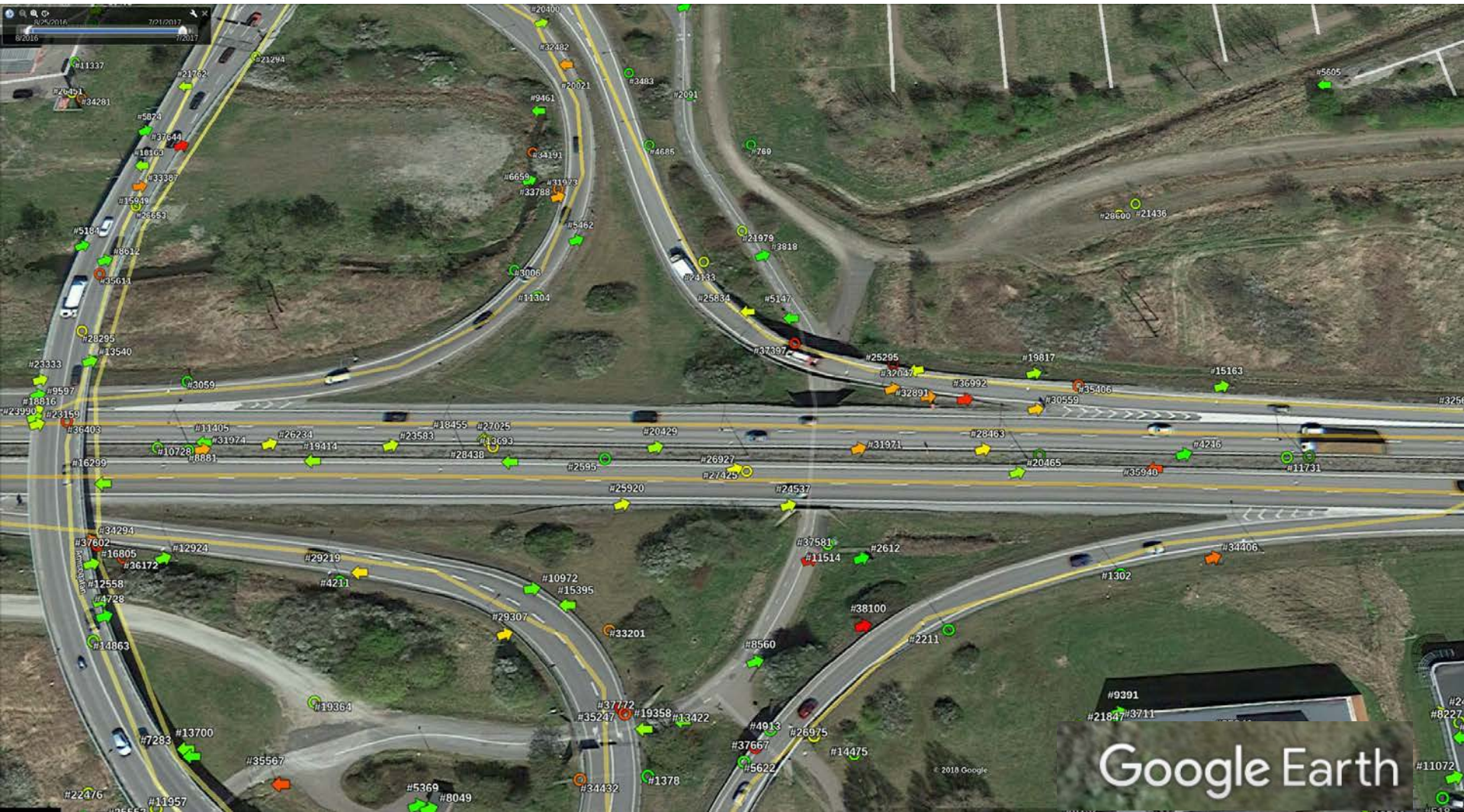


Number of measured GCPs:

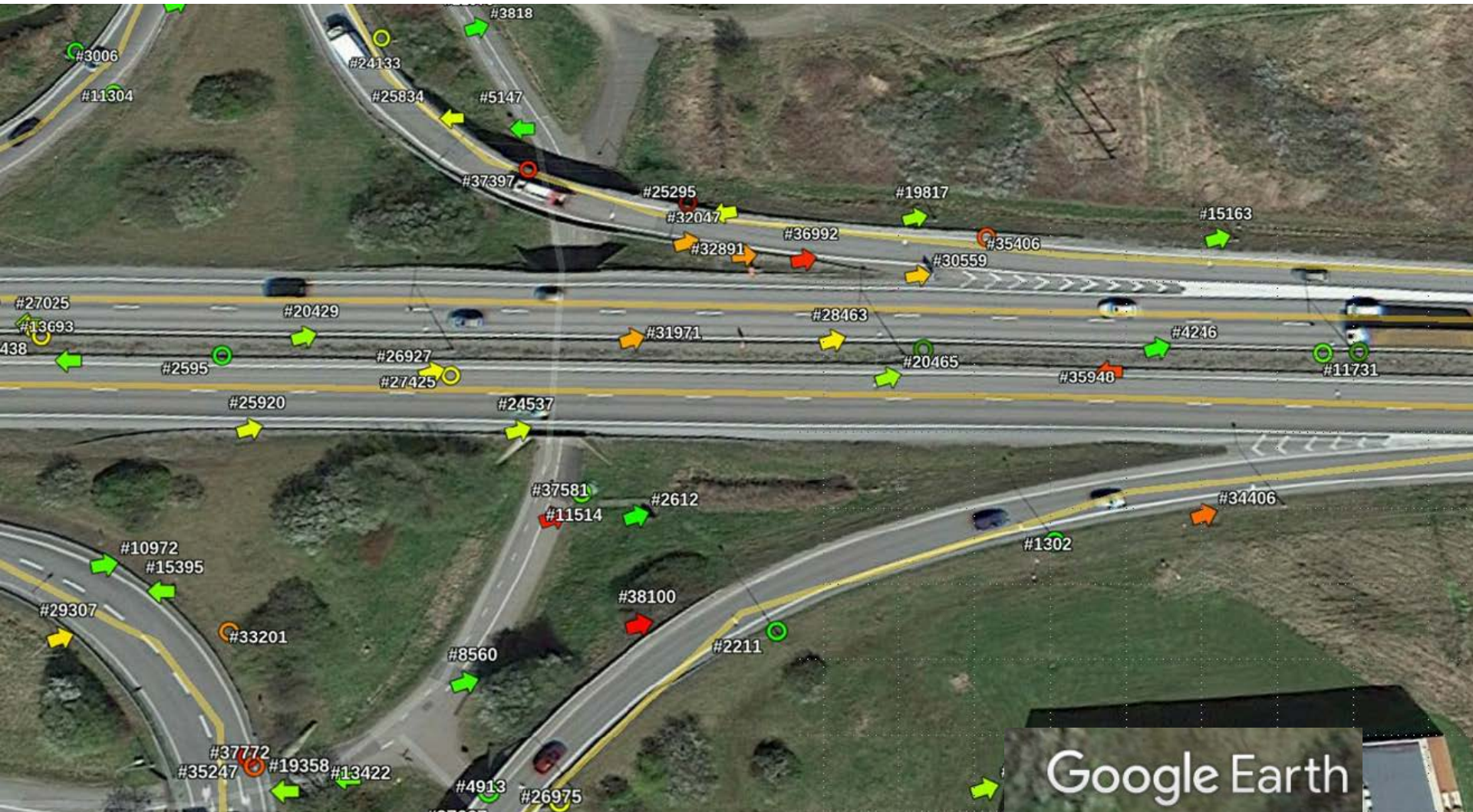
GCPs better 5cm accuracy: 1.386
GCPs better 10cm accuracy: 3.974
GCPs better 20cm accuracy: 9.518



Example: Gothenburg Söderleden – Detected and measured objects



Example: Gothenburg Söderleden – Enlargement



Coordinates and Estimated Location Accuracy of Object #1302

parameter	value	unit
reference frame	ETRF2000	
earth ellipsoid	WGS84	
latitude	57.644224773	deg N
longitude	11.988661196	deg E
ellipsoid height	40.7965	m
cartesian coordinate X	3346993.1986	m
cartesian coordinate Y	710733.1012	m
cartesian coordinate Z	5364670.3193	m
epoch	2017.536	
date	2017-07-15	
localization accuracy (range)	3.89	cm
localization accuracy (azimuth)	2.57	cm
localization accuracy (elevation)	5.76	cm
localization accuracy (X)	5.62	cm
localization accuracy (Y)	6.90	cm
localization accuracy (Z)	7.28	cm
localization accuracy (north)	2.94	cm
localization accuracy (east)	6.30	cm
localization accuracy (height)	7.05	cm
unit vector (range)	(0.4423, -0.7957, 0.4137)	
unit vector (azimuth)	(-0.8450, -0.2151, 0.4897)	
unit vector (elevation)	(-0.3006, -0.5662, -0.7675)	

Detected POI



2017-07-06

SCR: 15.55 dB



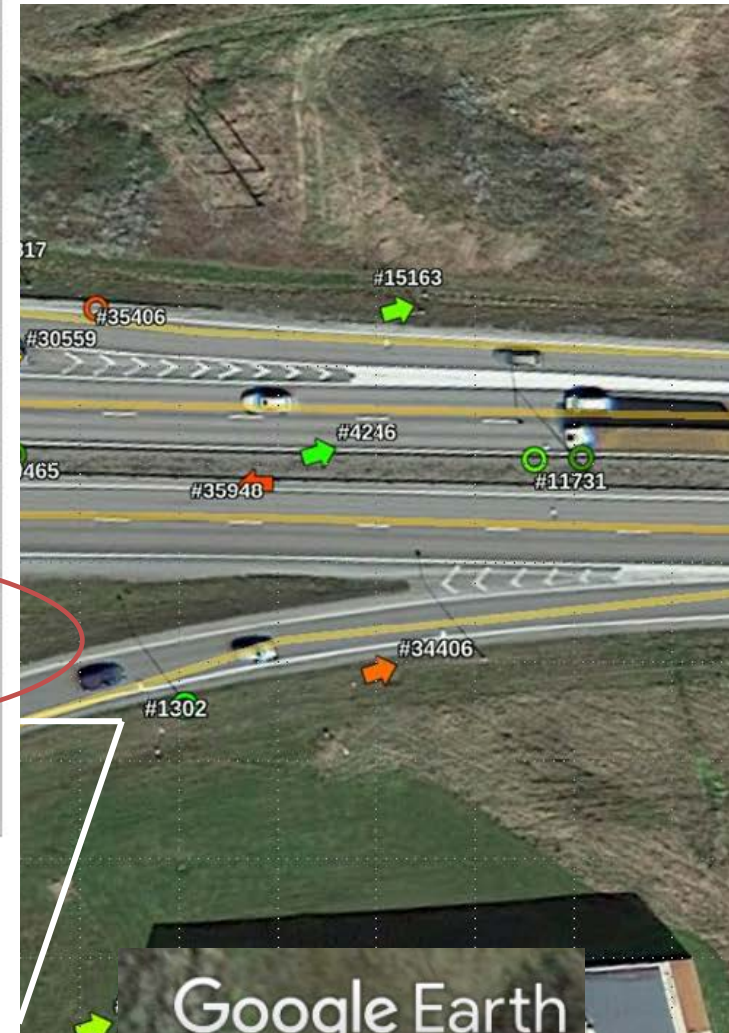
2017-07-14

SCR: 14.30 dB



2017-07-25

SCR: 14.77 dB



Google Earth

Object #1302: The light-pole acts as a corner reflector

The measured coordinates correspond to the base of the mast



How Does it Work?

GNSS Satellites

TerraSAR-X
with IGOR GPS-receiver

Satellite Orbit
known with 1 cm accuracy

Correction for
Ionospheric Delay

→ Signal Path
R

Correction for
Tropospheric Delay

Retro-
Reflector

Corrections for
Plate Tectonics

Corrections for
Earth Tides

- After applying all corrections the range measurement has an accuracy in the order of 1cm.
- At least 2 measurements from different orbit positions are necessary, in order to obtain 3D-coordinates



Applications

- **Geodetic Measurements**

We have measured the earth plate shift of Canberra / Australia to be 5.8cm pa and the postglacial uplift of Oulu / Finland to be of 0.95cm pa

(Dr. U. Balss, DLRF MF-SAR)

- **Use as Ground Control Points to register aerial images to produce maps with an accuracy better than 10cm**

Self-driving cars need precise maps to position themselves within the lane and absolute coordinates for the exact reporting of deviations in the map

- **Use as Landmarks for Ego-Positioning of cars**

Autonomous driving requires redundant systems



Landmark Navigation Using High Precision Fix Points From Radar-Satellite Imagery

Prominent
Fix Points
Along The
Road

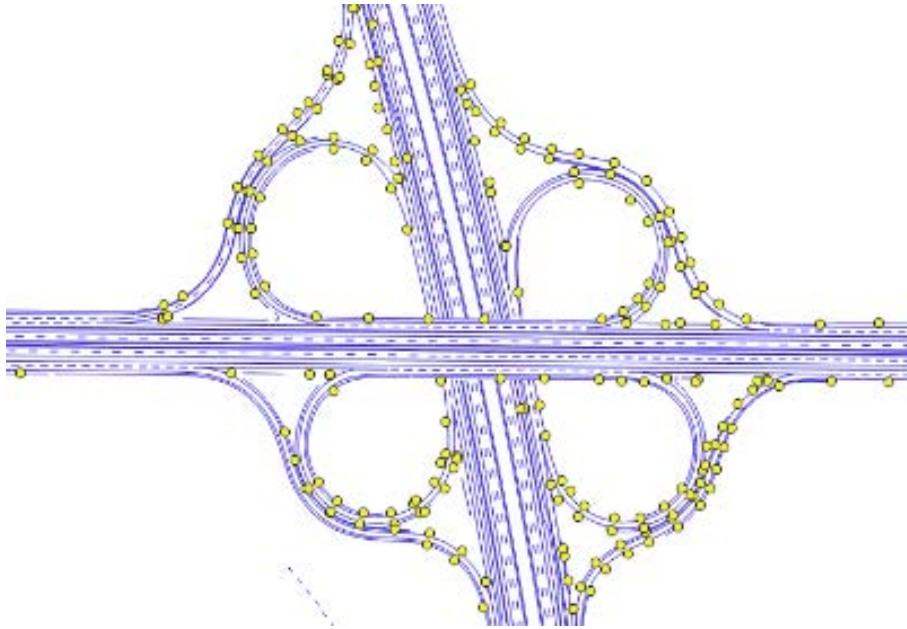
TerraSAR-X SpotLight Radar Image
München-Allach, A99 / A8, 

Identification
Of Fix Points
With Car Sensor

Determination
Of Car Position
With High
Precision



Simulation of Landmark-Navigation at interchange A99 / A94 east of Munich / Germany



Prof. T. Abmayr
M. Wimmer
D. Richter

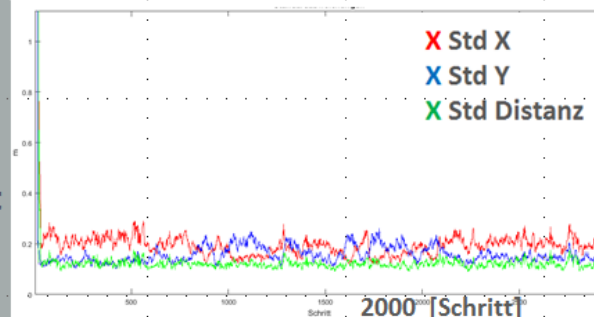


Results

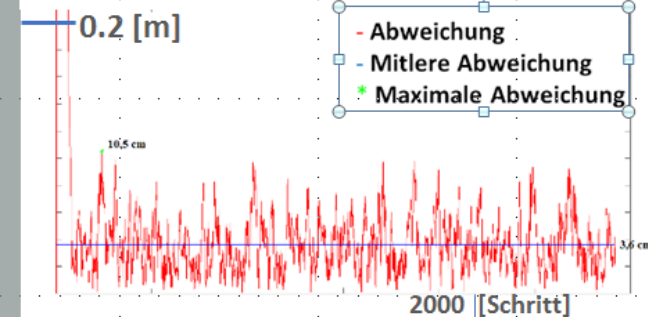
With Range Bearing Sensor

- Distance and Angle Measurement
- Sensor: LIDAR
- Accuracy: 0.1 m range
0.25° angle

Standard Deviation



Distance between real and
calulated position



Conclusions

- Based on TerraSAR-X radar image data, our system can deliver **global 3-D coordinates** of isolated point scatterers like lamp poles or traffic signs with an **accuracy** at the **lower decimeter level**.
- The coordinate measurements are performed **remotely**. It is no longer required to be on site.
- Applications are in **Geodesy**, the generation of **precise Road Maps** for Autonomous Driving and **Landmark Navigation**



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E04Car

Precise Mapping from Space
for autonomous vehicles

